APPARENT SUN-CRACK STRUCTURES AND RINGING-ROCK PHENOMENA IN THE TRIASSIC DIABASE OF EASTERN PENNSYLVANIA.

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The rocks deposited during the Triassic period in eastern North America, variously known as the New Red, Newark, and Jura-Trias, cross the State of Pennsylvania in a northeast-southwest strip averaging twenty miles in width. While they have in the past been the subject of considerable investigation, some of their most interesting features are as yet undescribed.[1]

About the middle of the 20,000 feet of sediments representing the period in Montgomery County there occurs a sill of diabase, which, although greater in size than the Palisade sheet of New Jersey, has attracted far less attention since it does not happen to be so located as to give rise to striking scenic effects. The total length of outcrop of this sill being over 40 miles, it would be strange if there were not a few exposures of its contact relations with the sediments, even in the absence of a great metropolis nearby as an inducement for railroad companies to pierce it by numerous cuts and tunnels; and, in fact, its upper contact has been observed at several localities northeast of the city of Pottstown. The rock surfaces exposed at these places by the removal of the metamorphosed shale beds present a rather startling appearance, being crossed by a rudely hexagonal network of light-colored lines, closely resembling sun-cracks such as are frequently found in the sediments. The best exposure, a photograph of which is shown in figure 1, Plate II, is on the east side of a road, opposite the house of Alexander C. Minshall, one-half mile north of Neiffer Post Office, which lies about three miles north of Limerick Square and two miles west of Zieglersville.

[1] The writer has been engaged for several years in studying the portion of this area lying east of the Susquehanna River, and has previously published two papers upon it: "The Newark Copper Deposits of Southeastern Pennsylvania," *Econ. Geol.*, III, 726–38, 1908; and "Contributions to the Mineralogy of the Newark Group in Pennsylvania," Thesis, University of Pennsylvania, 1909, *Trans. Wagner Free Inst. Science*, VII, 1–23, 1910. An abstract of this paper was read at the Pittsburgh meeting of the Geological Society of America, December, 1910, and published in *Bull. Geol. Soc. Amer.*, XXII, 718, 1911; and in completed form it was presented at the meeting of the Academy in association with the Mineralogical and Geological Section, May 21, 1912.

There can be no question, however, as to the igneous origin of the rock. When studied in thin section it is found to consist of interlacing laths of labradorite surrounded by augite similar to the contact facies of Triassic diabases which have been described elsewhere.[2] The lines turn out to be dikes, composed of coarser crystals of the same minerals (fig. 3, Plate II). These dikes vary from $\frac{1}{2}$ to 5 mm. in thickness, and penetrate into the rock to depths of several centimeters, gradually losing their identity as the size of grain of the background increases.

The explanation of this occurrence is apparently to be found in the tendency of magmas to contract on solidifying, exemplified in the well-known columnar structure of many basalts. In the course of the intrusion of the magma the outer portions were rapidly chilled by the cold wall-rocks, and solidified in correspondingly fine-grained form. At the same time there developed, perpendicular to the contact surfaces, hexagonally arranged shrinkage cracks. Into these the still liquid material beneath found its way, but since in the meantime the surroundings had become heated, cooling was now less rapid and larger crystals were formed.

The boulders which everywhere characterize the diabase areas often show on their surface a hexagonal-crack effect resembling at first sight that just described (fig. 2, Plate II). The two phenomena are, however, quite distinct, for thin sections of the rock beneath these cracks fail to indicate the existence of any structural peculiarity (fig. 4, Plate II), and the cracking is evidently caused by expansion of the surface layers during the exfoliation of the boulders under the action of frost.

The striking similarity of these two effects to one another, and of both to sun-cracks, is due, then, to the fact that all three have their origin in tension exerted uniformly in a plane, the normal result of which is, as is well known, the development of cracks at approximate angles of 120 degrees.

The blocks of diabase are occasionally collected into "boulder fields"—in Germany termed Felsenmeere, or rock seas—tracts often an acre or more in extent, which are practically barren of vegetation (because of the absence of soil), in striking contrast to most of the surrounding region (fig. 7, Plate II). Many of the boulders ring like a metal when struck, and under the name of "ringing-rocks" have attracted considerable attention from the inhabitants of the neighbor-

[2] Lewis, J. V.: *Ann. Rept., State Geol., New Jersey,* 1907, 115, pl. XVI.

hood, many a fantastic theory having been advanced to account for their formation. The principal localities of these ringing-rock fields are:

Narrowsville, Bucks County, on the edge of the plateau south of the Delaware River, 3 miles east of Kintnersville.

Shelly, Bucks County, 2½ miles northeast of the railroad station.

Spring Mount, Montgomery County, east of the Perkiomen Creek, one mile above Schwenksville.

Ringing Rocks Park, 2 miles northeast of Pottstown.

Blue-Rocks, 1 mile east of Elverson Station, Chester County.

Although most of these places are rather widely known and are frequently visited by outing parties, curiously enough no scientific description of them appears to have ever been published.

The manner of formation of the large rounded rock masses known as boulders, as described in text-books of geology, is as follows: The solid rocks at or near the earth's surface are traversed by numerous cracks, or "joints," usually intersecting in such a way as to divide them into roughly rectangular or rhomboidal blocks. Rain water, percolating downward along these joints, attacks and gradually decomposes the rock constituents, but since at the intersections of planes the action can take place in several directions at once, edges yield twice, and corners three times as rapidly as the flat surfaces, and as a result the ultimate shape attained by the blocks is that of a spheroid (fig. 8, Plate II).

Boulders thus developed usually remain surrounded by weathered rock fragments or the derived soil; but when running water finds its way around them, this finer material may be removed, leaving them exposed to view. Study of the above-mentioned occurrences has shown that this explanation is adequate to account for their formation. The boulder fields are always found at or near the base of the sheet of igneous rock, where the intensely metamorphosed underlying sediments form an impervious pavement over which streams of water flow; this can sometimes be heard, or even seen, through spaces between the blocks. Their exact position is determined by local conditions, such as the dip of the strata, which apparently must be less than 30°, the configuration of the hills, which affects the flow of the streams, and perhaps other factors. But the point calling for particular emphasis, in view of the popular opinion about the matter, is that there has been absolutely no "upheaval" or other violent disturbance to bring the boulders together, but that they have, quite to the contrary, been formed by the gradual breaking up and

washing away of material from the solid rocks originally occupying the ground.

The cause of the ring of the boulders when struck is no doubt to be sought in the peculiar rock texture. As seen in thin sections (fig. 5, Plate II), the feldspar crystals interlace to form a close network in which sound waves can readily develop. But this alone is not sufficient—the boulders must also be supported so as to be able to vibrate freely, just as is necessary with a bell, for thin sections of two of them found side by side, one ringing finely, the other not at all, show absolutely no textural difference (figs. 5 and 6, Plate II), but the former was loosely supported, and the latter wedged firmly, between other blocks.

It is to be concluded, then, that the "ringing-rocks" consist of boulders formed in the places where they are found by simple, normal processes of weathering and that their ringing qualities are due to the texture of the diabase rock of which they are composed.

Explanation of Plate II.

Fig. 1.—Sun-crack-like structure, upper surface of diabase sill, north of Neiffer P. O., Montgomery County, Pa.

Fig. 2.—Boulder of diabase showing exfoliation cracks, near summit of Spring Mount, Montgomery County, Pa.

Fig. 3.—Thin section of the rock of fig. 1, showing fine-grained diabase traversed by more coarsely crystallized dike. Crossed nicols. × 20.

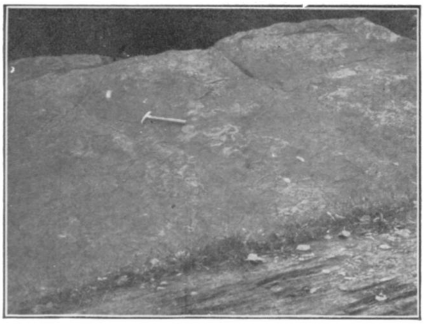
Fig. 4.—Thin section beneath an exfoliation crack, showing uniform size of grain, the lighter color along the crack being due to decomposition of augite, etc. Ordinary light. × 20.

Fig. 5.—Thin section of a rock yielding fine ring, Ringing Rocks Park. The banded crystals are plagioclase feldspar, the gray patches chiefly augite. Crossed nicols. × 20.

Fig. 6.—Same, from a boulder adjacent to the preceding, which failed to ring; entirely similar as to minerals and structure.

Fig. 7.—Boulder field, Ringing Rocks Park, northeast of Pottstown, Montgomery County.

Fig. 8.—Boulder formation in diabase, quarry at St. Peters, Chester County, Pa.



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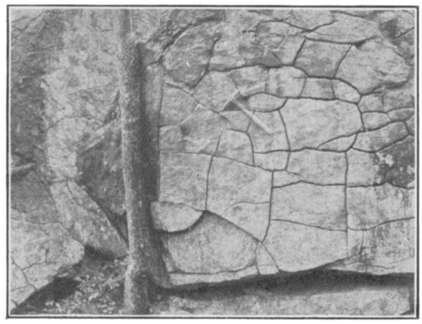

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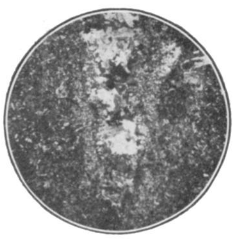

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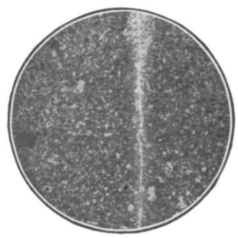

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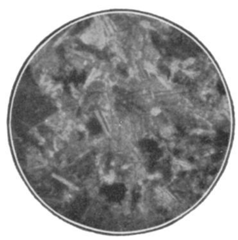

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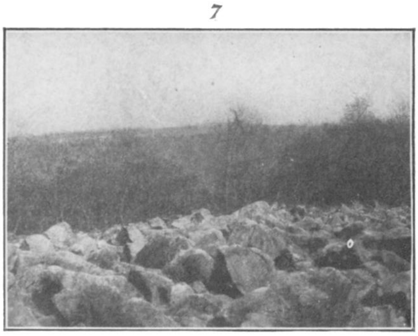

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WHERRY: SUN-CRACKS AND RINGING ROCKS.